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The ILLUMINATING ENGINEER

ELECTRICITY · ACETYLENE · OIL · GAS

Edited by LEON GASTER

10/6 Yearly.

THE JOURNAL OF SCIENTIFIC ILLUMINATION.

1/- a Copy.

OFFICIAL ORGAN OF THE
Illuminating Engineering Society.
(Founded in London 1909.)

This number contains the Account of the ***Annual Meeting*** of the Illuminating Engineering Society which took place on May 15th, and the ***Report of the Council*** for the Session Nov., 1916-May, 1917.

Other matters dealt with include:

THE FUNDAMENTAL PRINCIPLES OF GOOD LIGHTING—ELECTRIC SUPPLY COMPANIES AND PUBLIC SERVICE—THE EFFECT OF LIGHT ON SELENIUM AND ITS PRACTICAL APPLICATIONS—THE RELATION BETWEEN SUNLIGHT AND MOONLIGHT, &c.

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EDITORIAL.

The Annual Meeting of the Illuminating Engineering Society.

At the Annual Meeting of the Illuminating Engineering Society on May 15th the Report of the Council summarised the chief events of the session 1916-1917—the third year of the war.

The experience in regard to illuminating engineering was broadly similar to that recorded for the previous year, but the effect of the continued hostilities has been accentuated in various ways. Many aspects of illuminating engineering are necessarily in abeyance, and the choice of subjects for discussion of special interest at the present time was therefore timely. On the other hand, new fields for work have opened up. The Society has now several committees engaged in work for Government Departments, it has

been invited to form a committee to co-operate with the Cinema Commission in regard to the lighting of cinematograph theatres ; and it is represented on the London Safety First Council, which is studying the relation of street-lighting to safety and the prevention of accidents, and has already done good work in facilitating the uniformity of public lighting throughout the metropolitan area. The modifications in street-lighting recently introduced mark a distinct advance from the illuminating engineering standpoint, and the agreement on uniformity of practice throughout London is a significant precedent for the future.

The Society has suffered the loss of several valued members. The death of Professor Silvanus P. Thompson, which occurred shortly after the Annual Meeting last year, has been deeply felt, not only by the Society, but by the world of science. We are glad to note that the Council is considering an appropriate method of recognising his great services as President during the first four years of the Society's existence. Sir William Bennett, the President for the past two years, has taken a keen interest in the Society's work, in spite of many urgent calls upon his time for special and responsible war work. In thanking him for his services at the Annual Meeting Mr. F. W. Goodenough, the Chairman of Council, announced the nomination of Mr. A. P. Trotter as President for the coming session. Mr. Trotter's name is familiar to everyone interested in photometry and illumination, which has been his special study for many years. He has already rendered countless services to the Society at meetings, on the Council and on Committees, and his election as President will be greeted with acclamation by all the members of the Society, and all will agree that it is a privilege for the Society to have the benefit of his large experience and profound knowledge of lighting problems.

The most important announcement in the Report of the Council related to the formation, under the Department of Scientific and Industrial Research, of a Joint Committee on Illuminating Engineering of which, very opportunely, Mr. Trotter is the Chairman. The Report of the Research Committee of the Society, presented at the Annual Meeting last year, paved the way for this step and formed a basis for the statement of the Deputation which approached the Department on this matter on March 3rd. The appointment of the Joint Committee is a gratifying recognition of the importance of illuminating engineering as a field for research, and it is very satisfactory to note that the valuable work being carried on under the Department in many other fields is now to be extended to illumination.

Following the conclusion of formal business, a discussion took place on " Economies in Lighting in relation to Fuel-Saving." The account of this discussion will appear in our next issue, and we must defer detailed comment until then.

The chief point elucidated in the discussion was the comparatively small consumption of coal for lighting by supply companies, which, apparently, does not exceed six million tons per annum, *i.e.*, only 2½ per cent. of the total coal output. It is evident, therefore, that the prospects of saving in this field are not great compared with those existing in connection with power-supply and other sections of coal expenditure.

Nevertheless, the elimination of waste of light by improper use, which has always been an aim of the Illuminating Engineering Society, deserves attention, and it was suggested that the matter might be the subject of enquiry by a Joint Committee during the coming months.

Gas and Electric Supply Companies and Public Service.

We have often emphasised the idea that the duties of supply companies should include the study of the consumer's interests and the giving of advice as to the best use of the commodity supplied to him.

Supply companies have a public service to perform, and are necessarily dependent upon the public goodwill. A case in point is afforded by an experience of Mr. C. E. Clewell in the United States, which forms the subject of a note on pp. 117-118 in this issue.

The company concerned had taken over a plant previously privately owned, and found the administration in a bad state. The methods of assessment and collection of accounts were lax, the conditions of distribution were faulty, and there was little sign of appreciation on the part of consumers of the fundamental principles of good lighting. The new company set about reforms and promised better service at a lower cost. It appears, however, that the reforms in collecting accounts at first outran those in other directions. The consumers complained that their bills had increased and that the service had not improved. The company then asked Mr. Clewell to make an exhaustive enquiry, and he suggested a number of improvements practically all of which were energetically taken up, but in the subsequent two years they were unable to make good the lost ground. Eventually a petition in favour of the supply being taken over by the municipality was presented. At the hearing of this petition it was evident that some of the complaining consumers had no conception of the essentials of good lighting, and the company, on their side, were apparently not well equipped in staff and knowledge to meet charges under this head. The moral drawn by Mr. Clewell is that " poor lighting leads to public ownership." A company must render public service if it is to continue to exist.

In the future gas and electric supply companies will doubtless demand new opportunities for expansion, and the removal of restrictions which have hampered their development in the past. Mr. Vernier in his recent paper before the Institution of Electrical Engineers on " Wayleaves " contended that supply companies should be regarded not as mere dividend-earning concerns, but as doing an important public service. In order to justify this description companies must be prepared to cultivate more friendly relations with the consumer. The machinery of complaint departments should be overhauled. A satisfied consumer is a continual advertisement, a dissatisfied one a constant source of trouble. The more progressive companies no doubt take special pains to secure people of tactful personality and agreeable manners for such posts. Men or women entrusted with this work should be thoroughly trained in the technical side of the business and familiar with the standpoint of the consumer. Adequate salaries should be paid in order to place them in an independent position and above any possible reproach of yielding to undue influences. While loyal to the Company's interests they should not be too ready to assume that the consumer is wrong, but should hear all complaints with patience and courtesy and endeavour to remove misunderstanding rather than enforce routine procedure.

The Properties and Applications of Selenium.

On pp. 115-116 in this issue we refer to an interesting paper recently read before the Röntgen Society by Mr. E. Fournier D'Albe, dealing with the properties and applications of selenium. This substance has many possible applications, most of them, however, still in the experimental state. The author mentions one very striking example of its use, *i.e.*, to measure the light from distant stars. He contends that selenium is more sensitive to light than the human eye and that it might be possible, by proper appliances, to recognise the existence of faint distant stars such as cannot be seen by the eye even with aid of the most powerful telescope. This, if confirmed, is a remarkable result.

Among other applications are the use of selenium for the transmission of photographs by wire, its possible application to multiple telegraphy, and its employment in such devices as the optophone, which Mr. Fournier D'Albe has endeavoured to apply to enable the blind to read. It has also been used for the automatic extinction and lighting up of lights on buoys and beacons and it might conceivably be applied to control the artificial lighting of a factory, operating a switch by turning on the lights when the daylight illumination has fallen to a prescribed value. In a discussion before the Illuminating Engineering Society in 1916 Dr. Marchant communicated some particulars of a device involving the application of selenium cells to the control of street lamps, due to Mr. C. J. Turner of Hoylake. Up to a point the use of selenium for the automatic control of artificial light, as well as to photometry, appears promising. There are, however, difficulties to be overcome. One of the chief of these is the well-known "inertia" of selenium, which causes its sensitiveness to alter after exposure to bright light. The results at any moment are thus to some extent dependent upon its previous history. Another property which is not so serious when purely relative photometric observations are concerned, but obviously limits its application to comparisons between different types of lamps, is that it is, to some extent, "colour-blind," *i.e.*, it reacts to light of various colours in a manner quite different from that of the human eye. Another fact of importance, mentioned by Mr. Thorne Baker in the discussion of Mr. Fournier D'Albe's paper, is that selenium is apparently affected by atmospheric conditions. On a given day, for example, cells prepared in an identical manner gave different results in London, Paris and Manchester.

The study of all these peculiarities of selenium offers a most profitable field for investigation. Their examination demands the combined efforts of the chemist, the physicist and the photometric expert, and there seems no reason why selenium should not eventually be prepared in such a way as to be free from the present inconvenient properties. That there is room for development in this direction is apparently indicated from some results described in a recent American patent, also summarised in this issue (p. 116). The patentee claims to have prepared cells a thousand times as sensitive as those hitherto in use, and with a sensibility which remains unaltered over long periods of time. We shall await with interest further particulars of these and other investigations in this field.

LEON GASTER.

TRANSACTIONS

OF

The Illuminating Engineering Society.

(Founded in London, 1909.)

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

ANNUAL MEETING.

(Proceedings at the Annual Meeting held at the House of the Royal Society of Arts, 18, John Street, Adelphi, W., at 5 p.m., on Tuesday, May 15th, 1917.)

The Annual Meeting of the Society took place, as stated above, on Tuesday, May 15th, Mr. F. M. Goodenough (Chairman of Council) presiding.

The minutes of the last meeting having been taken as read, the HON. SECRETARY read out the following names of applicants for membership :—

Cross, P. H.	Electrical Engineer, 65, Tooting Bec Road, S.W.
Glew, F. Harrison ..	Chemist and Radiographer, 156, Clapham Road, S.W.
Iverson, H.	Engineer, 22, Hermiston Avenue, Hornsey, N.
Landau, A. L.	Chemist, 24, Leigh Road, Highbury Barn, N.5.
Pepper, W. J.	Inspector-in-Charge, The Gas Light and Coke Co., 182, Edgware Road, London, W.

REPORT OF COUNCIL.

The CHAIRMAN then called upon the HON. SECRETARY to read the Annual Report of the Council for the Session November 1916—May 1917 (see pp. 104-107), which contained the announcement that a Joint Committee on Illuminating Engineering had been formed under the Department of Scientific and Industrial Research. At the Annual Meeting in 1916 the Committee of the Society on Research had drawn up a list of subjects deserving of investigation. The appointment of the Joint Committee was the result of a Deputation from the Society, introduced by the President, which was received at the Department on March 6th in this year.

The resolution—"That the Report of the Council for the Session November 1916—May 1917 be formally adopted by the Society"—was then proposed by the Chairman, seconded by Mr. A. P. Trotter, and declared carried unanimously.

Mr. A. P. TROTTER, in seconding the adoption of the Report, explained the steps leading to the formation of this Committee, which would doubtless stimulate research on illuminating engineering. It was naturally desirable to devote

attention first to subjects of national or immediate industrial importance, but the field of work could be enlarged in time to come.

Vote of Thanks to President, Officers and Council.

Mr. J. F. Crowley then proposed: "That this Meeting extends a cordial vote of thanks to the President, Council and Officers of the Society for their efforts on behalf of the Society during the past twelve months."

In commenting upon the Annual Report, Mr. Crowley congratulated the Council on the continuation of the work of the Society in spite of all the difficulties incidental to the war. He thought they had made a wise choice of subjects for discussion. In the present circumstances the selection was naturally somewhat limited, partly because the consideration of many topics which would ordinarily interest the Society had to be deferred at the present moment, and partly because on other subjects connected with the war they could not say as much as they would like.

The virility of the movement was shown by the appointment of the Joint Committee under the Department of Industrial and Scientific and Industrial Research which should lead to valuable results.

Mr. Shaw Scott, who seconded, also referred to the Joint Committee, and referred to the valuable work being done under the Department in other fields which, he was glad to see, would now be extended to illuminating engineering.

The resolution was declared carried unanimously, and Mr. L. Gaster (Hon. Secretary) briefly returned thanks on behalf of the Council.

Election of Mr. A. P. Trotter as President.

The Chairman (Mr. F. W. Goodenough) referred in appreciative terms to the services during the past two years of Sir William Bennett as President. In spite of many urgent calls on his time owing to important and responsible war work, Sir William had yet found leisure to render very material help to the Society. In view of the nature of the subjects for discussion, the selection of a distinguished medical man as President had been opportune, and he felt that the Society owed a debt of gratitude to Sir William for his interest in the Society's work, and the aid he had given to them on a number of occasions, notably in introducing the Deputation to the Department of Scientific and Industrial Research.

He had now a pleasant duty to perform. At a recent meeting the Council had unanimously nominated Mr. A. P. Trotter as the President for the forthcoming year, and it fell to him to formally propose his election. There was no need for him to dwell on Mr. Trotter's long-standing association with photometry and illumination, and his constant interest in the work of the Society since its formation in 1909. At the present moment his election as President was rendered specially opportune by the fact that Mr. Trotter was also the Chairman of the Joint Committee on Illuminating Engineering, to which reference had been made.

Mr. L. Gaster, in seconding the resolution, recalled that when a meeting was called to consider the formation of the Society in November, 1907, Mr. A. P. Trotter, in the unavoidable absence of Sir William Preece, had consented to occupy the Chair. Ever since he had taken an active part in the work of the Society, both at meetings, on the Council, and on Committees, and the Society already owed much to his zeal on its behalf.

The election of Mr. Trotter as President having been carried with acclamation, Mr. Trotter briefly expressed his appreciation of the honour of becoming President, and, Mr. Goodenough being called away shortly afterwards, occupied the chair for the remainder of the meeting.

The formal business before the meeting was terminated by the following vote of thanks to the Royal Society of Arts, which was proposed by Mr. Trotter, seconded by Mr. Goodenough, and declared carried unanimously:—

> "That this meeting desires to express a cordial vote of thanks to the Royal Society of Arts for the courteous permission to make use of their rooms

during the past session, and records its appreciation of the encouragement and support which the Society has received."

Economies in Lighting in Relation in Fuel-Saving.

The Chairman then called upon Mr. L. Gaster to open the discussion on "Economies in Lighting in Relation to Fuel-saving."

Mr. Gaster, while dwelling on the need for fuel-saving in the present unprecedented circumstances, remarked that economy in lighting, in the sense of proper use of light and avoidance of waste, had always been a feature of the Society's programme. He quoted some figures relating to the coal supply of the United Kingdom, and referred to the experience of the Summer Time Act, by which a small but appreciable fuel-saving, varying however according to the nature of the district, had been recorded.

The problem would become of special interest in the winter months, and he thought that the intervening period might be utilised to consider where savings could profitably be effected. It seemed desirable to make a rough classification of lighting somewhat as follows:—

(1) Safety (*i.e.*, the use of illumination with a view to preventing accidents).

(2) The use of illumination in factories, munition works, and for other indispensable purposes.

(3) The use of illumination in the interests of public convenience.

(4) The use of light for luxury and spectacular purposes.

It was clearly undesirable to interfere with the use of light for the two first purposes, and the third category should also be left untouched except in urgent need, but in the fourth category some economies might possibly be made.

Any regulations with a view to making economies in lighting should follow broadly this classification, restrictions being applied in the order indicated.

The whole subject might well form the subject of consideration by a Joint Committee, acting with the support of the authorities, on which the Society should be represented. Such a Committee working during the coming months might accumulate information which would be not only of present utility but also of value for the future.

In the ensuing discussion the Assistant Hon. Secretary read a written contribution from Mr. Faraday Proctor, summarising some of the conclusions arrived at as a result of experience in connection with the Summer Time Act, and urging the economical use of fuel for power-production, especially through generation on a large scale rather than by the wasteful methods often pursued by small users.

Mr. J. F. Crowley likewise referred to the desirability of economies in power-production, seeing that lighting was responsible for such a relatively small proportion of the total fuel-consumption.

Mr. J. S. Dow remarked that although the saving in fuel to be achieved through diminished lighting might be small, the margin of fuel available for this purpose was also restricted. It was therefore essential that the best field for economy should be carefully selected. The avoidance of waste of light, which was one of the aims of the Society, was an aim worth pursuing at all times, but especially so at present.

The Chairman referred to some of the problems involved in fuel-saving, and quoted some data to show the relatively small expenditure of coal for lighting.

He also referred to the waste in some prevailing methods of street-lighting, especially the use of arc lamps, the globes of which had been almost completely obscured.

As regards the Committee, he thought he would be voicing the views of the meeting in suggesting that this matter might be safely left in the hands of the Hon. Secretary, who would no doubt take all necessary steps.

Mr. L. Gaster having briefly replied, the proceedings terminated, the Chairman announcing that the first meeting of the coming session would be held in November.

[*The full account of the Discussion on "Economies in Lighting in relation to Fuel Supply" will appear in our next number.*—Ed.]

REPORT OF THE COUNCIL FOR THE SESSION (November 1916 – May 1917).

(Presented at the Annual Meeting of the Society held at the House of the Royal Society of Arts, London, at 5 p.m., on Tuesday, May 15th, 1917.)

THE Report of the Council for the Session 1916—1917 appears in the third year of war and the circumstances alluded to in the Reports for the last two years continue. A number of members have joined the Colours, and there have been further additions to the number of those engaged wholly or partly on special war work. Nevertheless the activities of the Society have been continued without intermission.

MEMBERSHIP.

During the past year the membership has been well maintained. It is hoped, however, that in view of the increasing recognition of the value of the movement, further support will be forthcoming from companies throughout the country engaged in the supply of gas and electricity.

We have pleasure in recording that the Presidents of the Institutions of Gas and Electrical Engineers, Mr. A. E. Broadberry and Mr. C. P. Sparks, have kindly consented to act on the Council during their tenure of office.

Mr. A. E. Broadberry (President of the Institution of Gas Engineers), Mr. Harry E. Jones (President of the National Gas Council), and Mr. D. Milne Watson (Managing Director of the Gas Light and Coke Co.) have been created Vice-Presidents, and Professor A. Blondel has been nominated an Hon. Member of the Society in recognition of distinguished services rendered to the study of illumination and as one of the leading French scientists interested in this field.

The Society has sustained a great loss in the death of Professor Silvanus P. Thompson, whose able conduct of the affairs of the Society during its first four years of existence will not soon be forgotten. The Council desire to take this opportunity of again gratefully acknowledging these services, and are now considering an appropriate method of commemorating his name in connection with the Society.

In the death of Sir Corbet Woodall, the late Governor of the Gas Light and Coke Co., the gas industry has lost a distinguished representative, and the Society a valued Honorary Member. The Society has also lost through death two eminent Corresponding Members, Professor S. A. Rumi, of Genoa, and Professor Dr. Erismann, of Zurich, while several of its younger members, Mr. E. C. Laughton, Mr. A. L. Jones and Dr. Schwabacher, have fallen in the war.

MEETINGS OF THE SOCIETY.

Four meetings, not including the Annual Meeting, have been held during the Session.

At the opening meeting on December 15th, the Hon. Secretary gave an address on "Some Events during the Vacation, with Special Reference to War Economies in Lighting," in which reference was made to various points of topical interest such as Daylight Saving, Economy in Artificial Light, and Conditions of Illumination in the Streets, with special reference to accidents.

Mr. H. Blain, who was present on behalf of the London Safety First Council, expressed his recognition of the relation between defective lighting conditions and traffic accidents, and conveyed to the Society an invitation to be represented on the Council. The Society has since been represented on the London Safety First Council by its Hon. Secretary, who, in conjunction with the Chairman of Council, is likewise a member of the Sub-Committee on Street Lighting.

A record is being kept of present developments in street lighting, which

will no doubt be of considerable interest in the future.

The second meeting on January 16th was given up to a discussion on "The Lumen as a Measure of Illuminating Power," opened by Professor J. T. McGregor-Morris and Mr. F. W. Willcox. In view of the decision taken at the last Convention of the American Illuminating Engineering Society to rate lamps in terms of lumens, and the proposal of the makers of electric incandescent lamps in this country to adopt the same method of rating, this subject was opportune. In the course of the discussion the view was expressed that a descriptive pamphlet containing an explanation of the nature and use of the lumen would be useful in making this unit more generally known, and it was suggested that a small Committee of the Illuminating Engineering Society should be formed to draw up such a pamphlet. This proposal has been receiving the attention of the Council, and it is intended to proceed with this matter during the Vacation, preparatory to the coming lighting season.

On February 20th a paper was read by Dr. James Kerr, on "The Effect on the Eye of Varying Degrees of Brightness and Contrast." The paper and discussion were useful in bringing up to date our knowledge on the subject of effects of glare and contrast—matters which formed the subject of one of the first discussions before the Society in 1910. Earlier views on this subject have been revised as a result of fuller consideration of the effect of adaptation of the eye. It was shown that the principles discussed have an important bearing on many practical problems, such as the restricted lighting conditions in streets, and the illumination of the auditorium and screen in cinema theatres.

In connection with the latter aspect of the subject, two members of the Cinema Commission Enquiry, Dr. C. W. Kimmins and Mr. A. E. Newbould, were present, and conveyed to the Society a request from the Commission that a representative should give evidence before the Commission, and that the Society should appoint some of its members to co-operate with the Commission on a small committee to study lighting problems in cinema theatres.

It is hoped that the formation of such a Committee will be taken up with the co-operation of the cinematograph industry shortly.

On March 22nd a discussion was opened by Mr. F. Harrison Glew on "Fluorescence and Phosphorescence and their use to produce luminous effects." Mr. A. Blok and Mr. J. S. Dow dealt respectively with the photometry of such substances and their practical applications. At this meeting Mr. F. J. Cheshire (Director of Optical Glassware and Munitions Supply, Ministry of Munitions of War) presided. Apart from its great scientific interest, and its relation to the fundamental principles underlying the production of light by illuminants, the discussion formed a useful supplement to Dr. Kerr's paper, illustrating some of the properties of the eye which come into play at low illuminations. Interesting demonstrations were arranged by Mr. F. H. Glew, Mr. A. Blok, Mr. A. L. Landau, and Mr. C. C. Paterson.

It will be observed that during the past session the discussions have dealt with special topics arising through war conditions or problems which are exciting general interest at the present moment.

Scientific Work for the War.

Committees of the Society have been engaged in experimental work on certain special investigations for Government Departments in connection with the war, and many individual members have been employed on such work.

Scientific and Industrial Research.

The Department for Scientific and Industrial Research has been established by the Privy Council to assist in those investigations and developments which are beyond the reach of any one firm, or can best be carried out by combination of experience and co-ordination of work. The Research Committee of this Society has already prepared a list of subjects requiring attention, some of them being of pressing importance owing to the war. It was resolved to approach the Department, and a deputation of the Society was received on March 6th by Sir Wm. McCormick, the Chairman of the Advisory Council, at the offices of the Department in Great George Street, Westminster.

The Deputation consisted of the following officers and members of the Society :—

Sir William Bennett, K.C.V.O., F.R.C.S. (President).
Mr. A. P. Trotter (Senior Vice-President).
Mr. F. W. Goodenough (Chairman of Council).
Mr. Frank Bailey (Vice-Chairman of Council).
Mr. L. Gaster (Hon. Secretary).
Mr. A. Blok (Optical Glass Dept., Ministry of Munitions).
Lieut. S. R. Mullard, R.N.V.R. (R.N.A.S. Laboratories, Imperial College of Science, and Edison and Swan Lamp Research Dept.).

Each member contributed some account of the work in which he was interested and pointed out the directions in which research is needed.

The Deputation asked the Department to form a Joint Committee to deal with Illuminating Engineering. It was pointed out that the Society is in a specially favourable position to co-operate in such work, in view of the representative character of its membership, including gas and electrical supply companies, manufacturers of lamps and lighting appliances, and scientific experts.

Sir William McCormick, on behalf of the Advisory Council, promised to give the proposals of the Deputation favourable consideration and the result was the appointment of a Joint Committee on Illuminating Engineering, working under the Department. For the purpose of bringing it into touch with existing Committees members of the Engineering and of the Glass Committees were included.

The members of the Joint Committee are :—

Mr. A. P. Trotter (Chairman).
Sir Maurice Fitzmaurice, Mr. J. S. Highfield (representing the Standing Committee on Engineering).
Professor Herbert Jackson, Professor C. V. Boys (representing the Standing Committee on Glass and Optical Instruments).
Dr. C. Carpenter (South Metropolitan Gas Co.).
Mr. Leon Gaster (Illuminating Engineer).
Mr. F. W. Goodenough (Chairman of Council, Illuminating Engineering Society)
Captain J. H. Parsons, F.R.C.S. (Ophthalmic Surgeon).
Sir John Snell (Electrical Engineer).

The Committee has held its first meeting, the general procedure was discussed, and steps were taken to proceed with inquiries about those problems demanding urgent attention.

The formation of this Joint Committee under the Department of Scientific and Industrial Research is an important recognition of the aims of the Society, and there is every reason to hope that the extension to Illuminating Engineering of the valuable work already being done under the Department will be productive of useful results. For the moment it may be necessary to proceed first with investigations of national or immediate industrial value, but after the war, when the work of the Joint Committee will have developed, the range of subjects dealt with can be enlarged. The fact that machinery for the encouragement of researches now exists in the wide field of illuminating engineering is an important step.

Events During the Past Year.

As on the occasion of our last Report, there is again little to be said regarding International Congresses, which are naturally in abeyance owing to the war.

The Illuminating Engineering Society in the United States has been continuing its work with full activity. The Annual Convention was held in Philadelphia last September, and a series of lectures on illuminating engineering was given at the Pennsylvania University. These lectures will form a useful supplement to those dealing mainly with general principles, which were delivered at the Johns Hopkins University, Baltimore, in 1910.

Reference has been made to the resolution adopted regarding the rating of illuminants in terms of lumens at this Convention. Another item of interest was the presentation of the Report of the Committee on Nomenclature and Standards proposing a complete series of symbols, terms and definitions—a subject which has already received attention at the hands of our Society

In this country the course of events in regard to illuminating engineering has been broadly similar to that recorded for 1915-1916. The demands of the war have naturally caused many aspects of lighting to sink into abeyance, but other special fields of usefulness for the Society have been opened.

The relation between the diminished public lighting and the increased number of accidents in the streets has been the subject of discussion. Some statistics on the subject have been published in THE ILLUMINATING ENGINEER.* With a view to future progress in street-lighting it is desirable that these data should be amplified so that the relation between illumination and safety in the streets can be more clearly traced.

The recognition of this relation has been largely instrumental in bringing home the aims of the Safety First movement through which the municipal authorities throughout London have been brought into co-operation, with a view to treating street-lighting on a common basis. The recent alteration in the lighting conditions is, chiefly through this movement, being carried out in a uniform manner throughout the Metropolitan area. This is the first occasion on which the lighting of London has been dealt with as a whole and should serve as a significant precedent for the future.

Another step of importance has been the issue of the Report of the Committee appointed by the Home Secretary to inquire into the social and economic results of the Summer Time Act (1916). The Act has been extended to the present year, and it seems probable that the arrangement will be continued after the termination of the war.

The desirability of bringing about a further economy in fuel-consumption has led the Government to inquire into the directions in which economies in lighting may fitly be exercised. This subject is to be discussed at the Annual Meeting. It appears very desirable that any such modifications in lighting should be carefully considered during the summer period with a view to securing a minimum interference with safety and convenience during the winter months.

* November, 1916, p. 334; February, 1917, p. 38.

ADDITIONAL SUPPORT REQUIRED.

The Council are glad to be again able to record the gratifying fact of the Society being able to continue its labours, in spite of the unprecedented circumstances arising through the war. The considerations referred to under this head in their last Report apply with added force to the period 1916-1917. The Society is fortunate in benefiting by the arrangement by providing for THE ILLUMINATING ENGINEER to act as the official organ, and to undertake the publication of transactions the cost of which would otherwise be prohibitive. Many of the expenses incurred, such as those in regard to paper, printing, &c., have increased very greatly. The experience of the past year has served to emphasise even more strongly the desirability of securing additional funds in order to enable the work of the Society to be carried on in a satisfactory manner.

During the present circumstances the Council, as stated in their Report for the previous year, are unwilling to recommend any radical departure in this respect, but it is becoming evident that in the near future the Society must either secure a considerably enlarged membership or increase its present moderate subscription to £2 2s., as was originally provided at the time of the foundation of the Society, or secure substantial support from such institutions as benefit directly from the movement.

Another circumstance which has added to the difficulties of the present period is the considerable number of members who have joined the forces and from whom for the moment subscriptions may not be available. It is earnestly hoped that members who are still free to follow the work of the Society will aid the Officers of the Society in their task by prompt payment of subscriptions.

PROGRAMME FOR THE NEXT SESSION.

The Council is now engaged in preparing the programme for the next session. Members who are willing to read Papers are invited to notify the Hon. Secretary as soon as possible and to send in contributions during the vacation.

WILLIAM H. BENNETT, *President*,
F. W. GOODENOUGH, *Chairman*,
LEON GASTER, *Secretary*.

BRITISH SCIENCE GUILD.

Eleventh Annual Meeting.

On April 30th the Eleventh Annual Meeting of the British Science Guild took place at the Mansion House, the Rt. Hon. the Lord Mayor in the chair.

Sir Wm. Mather, the President, in announcing his retirement, introduced Lord Sydenham, as the President for the coming year.

The adoption of the Annual Report was moved by Sir Boverton Redwood, and seconded by Prof. R. A. Gregory. As usual, the report contains a useful summary of recent events in the direction of the application of science to industry and national needs, one item being a summary of the very considerable number of scientific committees which are now assisting the Government. In view of the creation of the Department of Scientific and Industrial Research it is also interesting to have on record corresponding steps being taken in Canada, Australia, and the United States. In France the Academy of Sciences has passed a resolution urging the institution of a National Research Laboratory, in view of the fact that at present there is in France no national laboratory with similar equipment and resources to those in England, United States, and Germany.

An address on National Reconstruction was given by Lord Sydenham, who pointed out many instances of the results of the national neglect of science, and mentioned many opportunities for its application in the future. The Empire contains all the great stable food supplies, raw materials of industry, and many rare metals, and even within the British Isles there are many sources of power at present untapped.

In advocating the fuller representation of science in the schools and universities, Lord Sydenham observed that scientific education was in no way antagonistic to the humanities.

The same view was expressed in the address by the Rt. Hon. H. A. L. Fisher, who said that technical and scientific training should be of such a character as to provide a liberal education as well as developing special abilities. Such a training should develop the sense of discipline and citizenship quite as effectually as the older educational systems. While our methods of teaching science in the schools were often considered well devised, we had not yet succeeded in making an appeal to the imagination of children and in leading them to apply their scientific knowledge in after life.

Mr. H. G. Wells declared that the great obstacle to educational reform was the over-emphasis of the importance of classical studies. Not only were too many hours expended in Latin and Greek, but the best teachers were always on the classical side, and the most gifted boys were attracted by scholarships, just as the ablest men were encouraged to devote themselves to classics as a preliminary to entering the public service.

As a result, the men in whose hands the destinies of the country rested were often without adequate knowledge of science and its possible applications.

He did not undervalue the beauty and worth of ancient philosophy and other knowledge derived through classical studies, but the path to such knowledge was often barred for ordinary men by the needless insistence that it could only be attained through the medium of the Latin and Greek languages. Thus a gulf was opened between scientific men and scholars, and neither could properly appreciate the other's point of view.

THE FUNDAMENTAL PRINCIPLES OF GOOD LIGHTING.

By P. G. NUTTING.*

IN our last number we gave a summary of some of the chief conclusions as regards the production of glare and the effect of contrast, arrived at by Mr. P. G. Nutting. The present article is based on some supplementary data given in a recent contribution by the same author in the Franklin Institute (March, 1917).

The article in our March issue contained a résumé of Mr. Nutting's conclusions on the effect of brightness on the three fundamental factors in vision, termed respectively *photometric sensibility*, *threshold sensibility*, and *glare sensibility*.

EFFECT OF BRIGHTNESS ON SENSIBILITY OF EYE.

All these factors are shown to change progressively as the order of brightness increases. Fig. 1 illustrates the relation

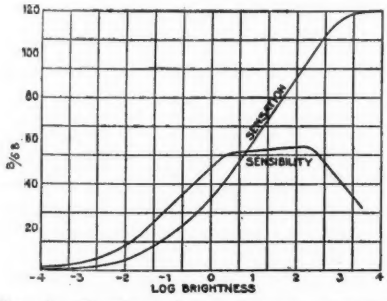

FIG. 1.—Showing relation between sensation and sensibility (power of eye to perceive contrast, B/dB), and brightness of field (millilamberts, B). Sensibility is expressed as a percentage; brightness in millilamberts is plotted on a logarithmic scale.

between stimulus and (*a*) total sensation, and (*b*) "sensibility," (*i e.*, the reciprocal of the percentage variation in brightness just perceptible).

Owing to the vast range of brightness to be covered the data on the abscisas scale are put in the form of logarithms, but it will be observed:—

(1) That the sensibility rises comparatively slowly from zero to about 1/100th of a millilambert (roughly equivalent to 1/100th foot-candle on a white surface).

(2) The increase is rapid from 1/100th of a millilambert up to about 10 millilamberts.

(3) From this value up to 100 millilamberts there is very little gain in sensibility, the curve becoming almost flat.

(4) Above 100 millilamberts the curve soon turns downwards, showing that increased illumination, so far from being a help, actually reduces the sensibility.

One can appreciate from these curves how a higher illumination becomes necessary for fine work involving slight contrasts, while a relatively low illumination suffices for handling large objects, or in dealing with black and white.

We can also understand why, when type is printed on dark-coloured paper, or on light paper with insufficiently dark ink or when dark materials are sewed with dark cotton, the illumination needs to be so much increased. For in such a case we reduce enormously the contrast between the working materials, and must therefore call for a higher order of illumination to enable this diminished contrast to be perceived.

Such data as the above appear to suggest a working basis for experiments on the amount of illumination required for various industrial purposes.

RATIO OF BRIGHTNESS CAUSING GLARE.

In the next figure we have, also in a logarithmic form for the sake of convenience, not only the sensibility of "discrimination" curve just described, but also the corresponding curves for the

* From a contribution to the *Journal of the Franklin Institute*, Vol. 183, No. 3, Mar., 1917.

threshold sensibility and the glare sensibility which were assembled in tabular form on p. 89 in our last issue. Reference to these curves enables us to see at once what order of brightness will cause glare at any particular illumination, and what brightness can be perceived as light immediately after one has been working in a given brightness of surroundings.

The figure is reproduced as showing the general course of these three factors, but, as its utilisation implies converting from logarithms, it is perhaps more convenient, when only rough results are wanted, to refer to the table given in our last issue (p. 89). It was pointed out then that the glare curve gives support to the suggestion that in ordinary lighting contrasts should preferably not exceed 100 : 1. Reference to the curve shows that with 1 millilambert (approximately 1 foot-candle) glare occurs with a ratio of rather more than 1000 : 1, so that by observing the above rule we should be well within the limit. On the other hand, at 1,000 foot-candles the ratio is only 10 : 1, while, if we used an illumination much beyond this, we should be in danger of reaching a glare ratio of unity, *i.e.*, a brightness which was in itself glaring, whatever the contrast with surroundings.

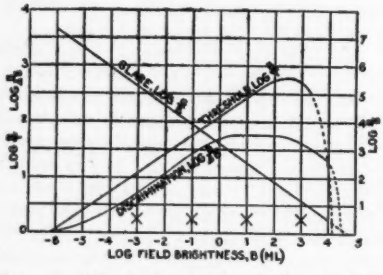

FIG. 2.—Showing general relation between field brightness and glare ratio, threshold, and discrimination.

An interesting question, apart from the contrast which produces glare, is the contrast which is most favourable to perception of detail. In the discussion on the lighting of rifle ranges before the Illuminating Engineering Society in 1915, and again in Dr. Kerr's recent paper this year, the drawbacks of excessive contrast were referred to,

But as yet this question does not seem to have been completely worked out. Mr. Nutting points out that the contrast which is sufficient to interfere with discrimination depends on the size of the central field where the variation in brightness is to be perceived. With a low luminosity diminishing the size of the field impairs sensibility, while at very bright illuminations the reverse is true.

There is some ground for believing that maximum sensibility is in general obtained with uniform brightness over the whole field of view, *i.e.*, a ratio of unity. Ives, for example, has contended that the sensibility attainable with a photometer reaches a maximum if the interior of the eyepiece is whitened and illuminated to about the same value as the photometric field. In this way, at all events, the possibility of glare is eliminated. It is to be noted that this depression of sensibility by extreme contrast is to be distinguished from the irritating effect known as glare. According to Nutting the former is a matter of total candle-power, and is not therefore relieved by a shade which merely diffuses the light. But the glare effect would be removed to a great extent by reducing the intrinsic brilliancy.

In considering the desirability of a uniform field with a view to obtaining the greatest sensibility it must be remembered that other factors come in when an interior is illuminated. For example, it would not be desirable to aim at completely uniform lighting. Although by so doing we approach a uniform field, we should practically eliminate shadows and destroy the contrast and relief on which the observation of solid objects depends. Apart from this, common experience suggests that the monotonous effect of such a system of lighting would be displeasing. In general the agreeable contrast would appear to lie somewhere between unity and 100 : 1.

RATE OF GROWTH OF SENSIBILITY OF EYE IN DARKNESS.

Another point of considerable interest is the length of time required for the eye to adapt itself to a lower order of brightness than that to which it has just been subjected. This would be useful as giving an indication how long it takes for the

eye to adjust itself after coming out of a brightly lit room into the dark streets, &c.

A good test of such adaptation is the threshold sensibility which, as we have seen, is temporarily raised by exposure of the eye to great brightness.

The course of adaptation, as obtained for brightness values of 0·1, 1·0, 10, and 100 millilamberts, is shown in Fig. 3.

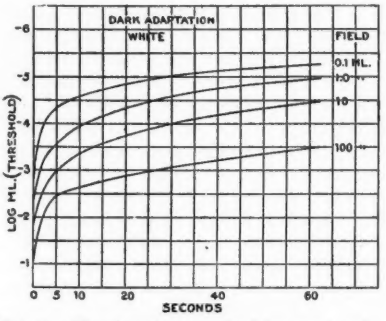

FIG. 3.—Showing time required for eye to adapt itself to perceive contrast after exposure to 0·1, 1·0, 10, and 100 millilamberts.

It will be noted that the curves in general are becoming horizontal after the comparatively short period of 60 seconds. The time of adaptation would naturally be much greater if the eye had been exposed to a brightness near the glare limit.

The following data, assembled in tabular form, are of interest :—

RATE OF INCREASE OR DECREASE OF SENSIBILITY.

	B_o=0, B=25 ml. Sensibility decrease.	B_o=25 ml., B=0. Sensibility increase.
Time.		
1 second	2·1 times	1·6 times
2 seconds	4·3 ,,	2·6 ,,
5 ,,	16·2 ,,	7·6 ,,
10 ,,	58 ,,	14·4 ,,
10 minutes	120 ,,	20·9 ,,

The rate of adaptation also depends upon the colour. It takes place twice as rapidly for blue light as for red light, and proceeds twice as far.

It is also interesting to observe the time taken for an eye to observe *a given contrast*. A person entering a dimly lighted room, after having been in comparative brightness, sees first the objects making strong contrasts with their surroundings, and only afterwards those with moderate contrast. The fainter contrasts may fail to become perceptible after quite a long wait. Out of doors at night, not only detail in shadow, but any detail involving weak contrasts, may also fail to become visible.

APPLICATION TO PRACTICAL LIGHTING PROBLEMS.

The data obtained in these tests has a direct bearing on practical lighting problems. The object of all lighting is to secure visibility of detail in those objects to which attention is directed. This detail may be : (*a*) Mere outlines of large objects, (*b*) the outlines of small objects, as in reading, and (*c*) the minutest detail which the eye is capable of perceiving. Apart from the question of the angle subtended by the object at the eye ("fineness" of work) the amount of contrast it presents with its surroundings is a most important factor.

As examples of class (*c*) may be mentioned photo-engraving, drawing, sewing, and many other arts and crafts where critical judgment is required.

For seeing in class (*a*) but little illumination is needed. The light of a high full moon supplemented by a little local lighting may suffice. Operating so near the threshold the eye is incapable of rendering detail except with harsh contrasts. Little attention need be paid to direction of light or the ratio of direct to diffused light, since the eye inevitably operates at a low efficiency. Glare, however, should be avoided at all costs, as the eye in its state of adaptation to weak light is particularly sensitive to dazzling effects, and a relatively weakly luminous spot of light may greatly reduce sensibility, and even render objects invisible.

Seeing in class (*b*) represents the great majority of ordinary working conditions, reading, writing, and accounting coming under this head, and also the lighting of school rooms, auditoriums, &c. Contrasts in the reflecting value of objects are usually ample, and the observation of fine detail is not required.

The specification of a discrimination factor of not less than half the maximum appears reasonable. The range of bright-

ness should, therefore, not fall below 0·1 millilamberts, and in practice values from 1—250, according to the illumination, are common. (Since in such work one rarely meets with materials that absorb more than 90 per cent. of light, a minimum illumination of one foot-candle, with a working value of two or three times this figure, should meet the requirements even of the more exacting kinds of work in this class.) The chief problem in this class of lighting is the provision of the proper ratio between direct and diffused light. Comfortable, acute vision requires that there should be neither extreme high lights nor dense shadows within the field of vision and that the details to be observed present sufficient but not too much contrast, *i.e.*, contrasts of over 50 : 49 and under 50 : 1.

With bright daylight in the open the scattered light from the sky contributes from about 16—40 per cent. of the total illumination received. On cloudy days nearly all the light is diffused. The golden mean for good average vision is probably not far from 30 per cent. diffused light.

If we view a landscape on an ordinary clear day through amber or yellow glass the view will appear very much brighter and more clean cut. The old explanation was that the yellow cuts out the purple haze, but it does a great deal more than that. It eliminates the diffuse light sky-light in all shadows because these shadows are lighted mainly by blue light, leaving the directly reflected sunlight almost unaffected because the blue in it is but a small fraction of the total luminosity. The consequence is that the shadows are everywhere deepened, producing a more clear-cut effect. This greater contrast may produce what is termed a " brighter " or more lively effect notwithstanding that the total luminosity is reduced.

In the highest form of lighting (Class *c*) the minutest detail has to be critically observed, and only the very best lighting conditions will prevent visual discomfort and eyestrain. Fine needlework requires perhaps as high-class lighting as any. Interest centres on a mass of fine bright images formed by the needle and fibres of textile goods. If all the light is diffuse these images broaden and merge and shadows disappear. Vision is strained by the attempt to pick up faint contrasts just at the limit of the power of discrimination. The most suitable local lighting is that limited to nearly a single direction. What is seen is a mass of cylindrical images of the source, and if the source subtends but a small angle, these images are sharp and contrasty.

In dealing with lighting there are two extreme views : on the one hand the view of those who ignore defects and tolerate any lighting that does not cause permanent injury to the eyes ; on the other the view of those who attach great importance even to minor and trivial sources of discomfort.

The true view lies intermediate between these courses. Our over-worked and much-abused eyes should be relieved from the wear and tear of the bad lighting conditions which we ourselves have put upon them. But it would be unwise and unnecessary to relieve them of all discomfort at all times, for this would surely result in a deterioration of the eye adaptability of the eye itself. Our standard should be the comfort of out-of-doors daylight lighting ; abundant light, 30 per cent. diffused—and by far the most important—but moderate contrasts anywhere.

ILLUMINATING ENGINEERING AND THE CINEMA THEATRE.

In view of the attention being given to lighting problems in connection with cinematograph work by the Illuminating Engineering Society in this country, it is of interest to note that a discussion on this subject took place at a Joint Meeting of the Cleveland Section of the American Institute of Electrical Engineers, and the Pittsburgh section of the Illuminating Engineering Society (U.S.A.) on April 16th.

The discussion was opened by an address by Mr. B. Perris, of the National Carbon Co., on " Illuminating Engineering in the Motion-Picture Industry."

THE RELATION BETWEEN SUNLIGHT AND MOONLIGHT.

By J. S. Dow.

Much work has been done on the photometry of daylight during the last few years, but the writer cannot recall a recent attempt to relate photometrically the intensities of sunlight and moonlight.

Astronomically the problem is of some interest as furnishing a rough check on the distance of the moon from the earth, and as a verification of the fact that moonlight is merely due to reflection of the sun's rays. Owing to the number of variable or unknown factors, one cannot expect any great precision in such a calculation. The object is to show that the value of full moonlight illumination can be roughly predicted from the measured value of direct sunlight. It is sufficient for our purposes if the calculated value of moonlight is found to be *of the same order* as that actually measured.

The diameter of the moon is approximately 2,160 miles, its distance from earth approximately 240,000 miles. The distance of the sun from the earth (approximately 93 million miles) is sufficiently great for us to assume that this is also its distance from the moon. The error in this assumption is within one per cent. On this understanding the actual distance of the sun need not enter into the calculation.

The starting point in our calculation is the value of the illumination (on a surface perpendicular to the sun's rays) derived from full sunlight with an unclouded sky. This value is variable according to the period of the year and the locality, but in England probably reaches a value with an unclouded summer sky of about 10,000 ft.-candles.

The illumination received by the moon should therefore be of about the same value but for the fact that the moon has no atmosphere and the sun's rays do not suffer the resulting absorption as in the case of rays reaching the earth. But if we remember that the light from the moon has likewise to pass through the earth's atmosphere in reaching this planet, it seems justifiable to ignore this absorption, which may be regarded as cancelling out.

Let us assume, therefore, that the illumination on the moon's surface also reaches 10,000 ft.-candles. Our next step is to calculate the approximate brightness and candle-power of the moon. If the moon's surface had a reflecting power of 100%, its brightness would be $10{,}000/\pi$ candles per square foot. Naturally we do not know enough of the moon's surface to determine its average reflecting power. It is believed, however, to consist mainly of volcanic rock, whose reflecting power would probably not exceed 20 per cent. A rough check on this value is obtained by determining the apparent surface-brightness of the moon by a direct measurement through the Lumeter or other suitable photometer. Nutting has given this value at about 1,000 ft.-candles. The author's measurements of the clear full moon on a clear night have given somewhat lower values. (In this determination we again ignore the factor of atmospheric absorption, but this, as explained above, may be regarded as eliminated owing to a similar error having been made in the estimate of the illumination received by the moon.)

We shall probably be within the limit by taking the surface-brightness of the moon as 1,000 ft.-candles, or $1{,}000/\pi$, candles per square foot. This figure is not unreasonable when we recall that, apart from the probably low reflecting power of the moon's surface, the surface will not obey Lambert's law exactly, and, being spherical, will allow a certain portion of the rays to glance off obliquely in direct reflection.

Since we have started from the illumination perpendicular to the sun's rays, we

must next take the projected area of the moon which is

$$\frac{\pi \times (2160 \times 5280)^2}{4} \text{ square feet.}$$

The approximate "apparent" candle-power of the moon is therefore :—

$$\frac{1000 \times \pi \times (2160 \times 5280)^2}{\pi \times 4}$$

and the illumination produced at the earth's surface (again perpendicular to the direction of the moon's rays) at full moon, with a clear sky, and with the moon at its zenith, should be about :—

$$\frac{1000}{\pi} \times \frac{\pi \times (2160 \times 5280)^2}{4 \times (240{,}000 \times 5280)^2} =$$

0·02 ft.-candle approx.

Actual measurements made by the author under the above conditions give about 0·015—0·025 ft.-candle, which, considering the many variable and unknown quantities, is remarkably near the calculated figure.

The above calculation is only given as a rough indication of how moonlight and sunlight may be related photometrically. By taking special precautions to allow for the altitude of the sun and moon at which measurements are made (and the resulting depth of atmosphere through which the rays penetrate) and by endeavouring to secure identical atmospheric conditions in both cases, a more exact result might be obtained.

It is interesting to note that the range of illumination between moonlight and sunlight, about 1 to 500,000, corresponds with well-defined limits in the state of adaptation of the eye. The lower limit is about the value where colour-discrimination is getting difficult, and where the Purkinje effect becomes very pronounced—where, in fact, "dark-adaptation" has well set in. The higher limit, according to Nutting, is approaching the brightness value to which the eye cannot adapt itself—the limit of absolute glare.

AWARDS OF THE AMERICAN MUSEUM OF SAFETY.

Four out of the five gold medals awarded annually by the American Museum of Safety have now been made public. The Anthony N. Brady Memorial Medal, awarded to the electric railway company which in the year of the award has done most to preserve the safety and health of the public and its employees, has been awarded to the Connecticut Company.

The Scientific American Medal, awarded for the most efficient safety device invented within a certain period of years and exhibited at the Museum, goes to the Pullman Company for the Dean end frame for passenger cars.

The Traveller's Insurance Company's Medal, awarded to the American employer who has rendered striking services in protection of life and limb of workers, goes to the Commonwealth Steel Company of St. Louis.

The Louis Livingston Seaman Medal, awarded for progress and achievement in the promotion of hygiene and the mitigation of industrial diseases is awarded to the Julius King Optical Company of New York, in recognition of its scientific investigation of the effect of coloured glasses to be worn by workmen whose eyes are exposed to the blinding glare of molten metal, oxy-acetylene and electric arc welding, &c. The glass recommended is designed to check the ultra-violet rays without unduly impairing the transmission of visible light.

SOME PROPERTIES AND APPLICATIONS OF SELENIUM.*

By E. E. FOURNIER D'ALBE.

THE application of selenium to photometric problems was proposed many years ago. It has long been known that this substance is affected by light, its resistance diminishing considerably under the influence of illumination, though the rays which produce the most powerful effect are not necessarily those to which the eye is most sensitive.

This property of resistance to light was discovered by Willoughby Smith in 1873. Selenium cells are made up of deposits of selenium in the form of grid or spiral, the aim being to present as large a surface as possible to the light and to diminish the resistance to a convenient figure by giving the conducting surface a very large sectional area but a relatively small length. In the construction of such cells Mr. Fournier d'Albe uses a porcelain plate, coated with graphite in which grooves are engraved by means of a diamond. The whole surface is then covered with selenium, which must be prepared specially so as to have the requisite sensitiveness to light.

Such cells have been used to measure the light from distant stars. Minchin succeeded in this way in measuring the brightness of the Jupiter, Venus and Capella, but, according to Mr. Fournier d'Albe, it is possible, by using a suitable telescope, to discover stars of even the seventeenth magnitude. It is possible to use currents even below 10^{-11} amp. With the naked eye one can just detect stars of the sixth magnitude, whereas with selenium one should be able to detect stars of the ninth magnitude. By the aid of a telescope, used in conjunction with selenium, it might be possible to locate stars which are absolutely undiscernible through the eye.

Clearly, if in selenium we have a means of revealing light too faint for the eye to perceive, this is in itself a most important result.

The chief difficulty in using selenium for photometry is the time necessary for the recovery of the material after exposure. One must use comparative methods. One may, for example, place the cell between the sources of light to be compared and rotate it, and then note whether any dissymetry is observable in passing from one source to the other. Apart from this, selenium, as is well known, is " colour-blind " to some extent, there being strong reaction or resonance in the extreme red. One can also obtain reaction from the infra-red rays and, to a limited extent, from the ultra-violet.

The application of selenium to the working of automatic shutters in a camera has been suggested. If this were practicable we should never have to trouble about exposure, the selenium acting as a perfect control. But the advantages so gained would be outweighed by the inconvenience of introducing relays.

By the use of flashes of light, acting by a siren-disc arrangement at regular

* Abstracted from the *Journal of the Röntgen Society*, April, 1917.

periods on selenium, thereby making a musical scale, a form of multiple telegraphy might be developed. By such a system it would be possible to send a number of different messages along the same wire. By means of the photographone sounds can be caused to give rise to corresponding alterations in the light from an electric arc; this in turn, by reacting on selenium, might be made to reproduce sounds. In Italy the photographone has been applied to the problem of producing sounds in exact synchronism with the movements of actors in a cinematograph display.

Phototelegraphy, the transmission of pictures along a wire by the use of selenium, has been carried to quite a practical stage. This was first done by Shelford Bidwell and subsequently developed by Korn, who transmitted pictures by dividing them into strips and sending each strip to the receiving apparatus at the other end of the line. Selenium, however, has been largely replaced by swelled gelatine for this purpose. Such a development almost brings within sight of practical achievement the dream of "television"—the seeing of distant objects through the medium of a wire. If one could transmit pictures with sufficient speed along a wire this might become feasible.

Among other interesting applications may be mentioned the use of selenium to control the lighting of buoys and lighthouses, the wireless selenium telegraphy invented by Graham Bell, and Bell's "photophone," by which intermittent light falling on selenium is made to set up a sound in a telephone.

The idea is somewhat differently developed in Mr. Fournier d'Albe's "optophone," a device intended to facilitate reading of type by ear, which may be of service to the blind. By arranging a scale of frequencies to denote various letters, and by exciting these timed vibrations by the transmission of light through transparent letters, it is possible to identify each letter by the sound.

An important matter, affecting some uses of selenium, was referred to by Mr. Thorne Baker in the course of the discussion—namely, the effect of the atmosphere upon selenium. The variation of atmospheric conditions in Paris, London, and Manchester, for example, on any given day, would give rise to quite different results. This was a difficulty that required to be overcome in the transmission of pictures by selenium.

SELENIUM CELLS OF GREAT SENSITIVENESS.

THE *Electrical World* for April 23rd records an interesting claim for the improvement of selenium cells. According to a patent, No. 1,219,432, F. C. Brown has succeeded in making cells with a sensitiveness a thousand times greater than those hitherto constructed. This result is accomplished by the production of the crystals by sublimation, and the crystals being allowed to absorb argon, helium or neon gas at a temperature below that of the crystal-formation. Both large crystals and those of microscopic size were studied. It is claimed that after being exposed to most intense light twenty-four hours a day for thirty-five days in succession, the crystals showed no appreciable deterioration, and one cell, when subject to ordinary conditions of use, was found to possess the same sensibility after a period of a year.

GOOD ILLUMINATION—AN ASSET TO SUPPLY COMPANIES

IN a recent article in the *Electrical World*, Mr. C. E. Clewell narrates a most interesting episode in the lighting of an American city, showing the results of insufficient education of the consumer in the use of his light to the best advantage.

The trouble arose in the borough of Catasauqua, where, in May, 1915, Mr. C. E. Clewell was asked to make an exhaustive enquiry into the grounds of public dissatisfaction with the lighting arrangements. It is stated that the circumstances in this case were unusual, no difficulty having been raised in the remaining 98 per cent. of area served by the same company, but nevertheless Mr. Clewell's comments would doubtless have a bearing on conditions in many cities—and not only in the United States.

Shortly before 1915 the old privately owned plant was bought up by the Lehigh Valley Light and Power Co., a concern which supplies twenty or more municipalities in the State of Pennsylvania. The company immediately set about a reform in many directions. Antiquated meters and lax methods of rendering and collecting accounts were improved and at the same time the consumers were promised better light and cheaper service.

Nevertheless, in spite of the general introduction of metal filament lamps (instead of carbon filament lamps which had been generally used prior to that time), the consumers continued to complain of unsatisfactory lighting conditions and higher bills. In the latter respect the Company was apparently reaping the result of the lax methods of charging and collecting prevalent before they took the business over. But when Mr. Clewell undertook a survey in 1915, a number of circumstances unfavourable to good illumination were revealed. For example, while graphic records showed a fair constancy in the voltage at the sub-stations, considerable variations at the consumers' premises, due to the inadequate distribution arrangements of the old company, were found to exist.

An equally important circumstance was the neglect of proper lighting appliances and methods of applying the light provided. Bare lamps without any well-designed reflectors were usual, and it is not surprising that in the circumstances fault was found with the illumination, although in many cases it was the consumers' neglect to use suitable lighting shades and reflectors that caused the trouble.

As a result of his investigation Mr. Clewell made a number of suggestions, essentially all of which were accepted and strenuously undertaken by the Company during the two years that followed.

The defects to which Mr. Clewell drew attention were substantially as follows :—

(1) Indicated voltage in residences showed considerable variations from standard value. Distribution circuits probably at fault.

(2) Voltage rating of lamps employed shows wide variations.

(3) General use of bare lamps for residence lighting.

(4) Education of consumers in the use of proper shades and reflectors should be started.

(5) Consumers should be told that lighting is best judged by the way objects to be seen are illuminated and not by the glare from the lamps.

(6) Consumers are in general using lamps of larger size than is necessary. Smaller lamps with suitable reflectors may actually result in improved illumination.

(7) Discourage the use of clear glass reflectors.

(8) Rearrange distribution circuits so as to supply some standard voltage to all residences.

(9) Standardise on some definite lamp voltage.

Practically all these recommendations were adopted by the Company. Besides making good technical defects canvassers were engaged to instruct the consumers and deal with complaints. Nevertheless, the lost ground could not be made up and eventually a demand was lodged for the supply to be taken over by the municipality.

At the hearing there was very general belief expressed that the bills were higher than formerly and the service less satisfactory. Many of the complaints were clearly absurd and showed marked lack of knowledge of illumination on the part of consumers. Thus one witness, when asked if he used reflectors with his lamps, said, "No, I never use reflectors or shades; I find that the light is worse with reflectors than without them." Yet the actual conditions in the hotel referred to were about as bad from the lighting standpoint as they could possibly be.

The incident is interesting as showing how "public service" is coming to be associated with the supply of gas and electricity. To leave the consumers in a state of ignorance on illumination is to court disaster. At an early stage their sympathy must be sought, and much patience must be exercised in gaining their confidence and in leading them to believe in the advice given. In this case the Company, in spite of their belated efforts, failed to make good the lost ground, one circumstance which told against them being that while the accuracy or inaccuracy of statements regarding bills was readily checked they were less ready to formulate immediate answers to charges of bad lighting.

It is essential nowadays not only for a company to cultivate the confidence of consumers and study their requirements from the start, but also to maintain a staff of experts trained to understand lighting problems and able to give the best advice. It is often no easy matter to put things right when suspicion and animosity have once been excited.

The whole question deserves very careful consideration by supply companies in this country, especially at the present time. During the war companies have been faced by special problems. On the one hand, there has been a tendency to raise rates, on the other, difficulties in paying close attention to consumers' needs, owing to shortage of staff.

Nevertheless, companies would be well advised to keep their machinery for personal contact with consumers complete, and even to make more assiduous efforts in this direction. The effect of the illuminating engineering movement has been already to make the public more discriminating in regard to lighting matters. Supply companies, on their part, would derive much benefit from a more intimate connection with the movement, and by taking a more active part in the education of the public in regard to illumination.

SHORT NOTES ON ILLUMINATING ENGINEERING.

HOW TO SECURE EFFICIENT AND ECONOMICAL LIGHTING.

According to the *Electrical Review and Western Electrician*, a bulletin has been issued by the Sealer of Weights and Measures in Massachusetts, containing some popular information on the use of electricity, and the possibilities of avoiding waste.

The Commissioner states that meters are often blamed for bills that seem unduly high. In reality defects in meters are rarely responsible for high bills, the chief causes of which are: (1) Dark weather, (2) additional lamps installed or lamps of higher power, (3) the use of dim or obsolete lamps which should be replaced by new ones, *e.g.*, carbon filament lamps instead of tungsten lamps, (4) lamps left burning in closets, attics, &c., (5) laundry irons, toasters, or other appliances used to an exceptional extent, (6) defective wiring, (7) machinery that is not properly oiled, and (8) errors in meter-reading.

CALORIFIC VALUE OF GAS PROPOSED IN THE UNITED STATES.

In a recent paper entitled "Some Notes on Gas Standards" before the Illuminating Engineering Society (U.S.A.), Mr. W. R. Addicks emphasised the growing importance now being attached to a calorific standard for gas. In the year 1915 Canada adopted substantially the same standard as Great Britain in this respect.

At the last annual meeting of the American Gas Institute the following resolutions were adopted:—

Resolved: That the total heating value in manufactured gas best represents its quality for standard requirements; and

Further resolved: That the American Gas Institute recommends the adoption of the total heating value as the only standard basis of rating the quality of all manufactured gas distributed in the United States.

LIGHTING THAT FITS NIGHT WORK.

The March issue of *System* contains an article by Mr. L. Gaster under the above title. Illustrations of typical factory installations are reproduced and the chief arguments in favour of good lighting from the economic and hygienic standpoints are summarised.

Figures are quoted to show that the cost of lighting in general forms but a small fraction of the wages bill. For example, it is calculated that in the case of skilled labour the running cost of the lighting provided per man during a normal day's work is roughly equal to the amount paid to him in wages during only three minutes of his time. If, therefore, as a result of better illumination the worker was able to save only three minutes on his job, this alone would cover the lighting expenditure.

MORE EXAMPLES OF FLOOD-LIGHTING.

Some time ago we described the flood-lighting of the Statue of Liberty in New York Harbour We note that the same method was used to illuminate the Capitol Building in Washington on the occasion of the inauguration of President Wilson on March 5th.

The subject of floodlighting is to be discussed in two forthcoming papers before the Illuminating Engineering Society, U S.A. Its use for outside illumination of public buildings has received official recognition in the United States, and in the future the possibilities of the system will have to be considered by lighting engineers in this country.

Recent issues of the *Electrical World* contain some account of the application of this system of lighting for purely utilitarian purposes. For example, at Greensboro' (N.C.) a sub-station of the Southern Power Co. makes use of a lamp in an automobile reflector for lighting a number of oil switches. This section was built without ceiling or wall lights, and numerous leads from them make the placing of lamps in the vicinity inconvenient. Accordingly the flood-light has been installed to enable the switches to be observed from a distance. The unit can be turned in any direction so as to strongly illuminate any object that requires attention.

Another interesting development is reported from New York city, where the central station companies are now arranging to flood-light all the bridges over the East River.

Projectors have been placed under the arches of the bridges, along the waterway, and round the stone piers, to enable the river to be easily surveyed and closely guarded. Danger signs to keep boats away from the bridges have also been posted and illuminated.

LIGHTING A SWIMMING BATH WITH SUBMERGED LIGHTS.

Submerged lighting of a swimming bath is being installed at Seattle, Washington, large specially designed waterproof automobile headlights being employed. Fifteen such units have been installed at intervals of 10 feet.

This novel method of lighting is said to have been very effective, and deserves attention in the interests of safety.

SAFETY FIRST AND THE RULE OF THE ROAD.

The London "Safety First" Council proposes to issue a series of leaflets indicating measures to be taken in the interest of safety. Leaflet No. 1 deals with "Hints to Drivers of Horsed and Motor Vehicles and to Cyclists." Concise directions are given as to hand signals indicating the intended movements of the vehicle, coming out of side streets or yards, front and rear lights after sunset, &c.

The following rule is an ingenious statement of the "Rule of the Road," a rhyme deserving to be remembered :—

"The Rule of the Road is a paradox quite,
In Riding or Driving along,
If you keep to the **Left** you are sure to be *right*,
But if you go **Right**, you are *wrong*.

Copies can be obtained from the Hon. Secretaries of the London Safety First Council, 31, Westminster Broadway, S.W.1.

DETECTION OF FOREIGN METAL BODIES BY RONTGEN RAYS.

As is well known, Röntgen rays provide one of the most effective means of locating foreign objects in the human body, and have been extensively used for detecting splinters of shell, &c., since the war began.

In a recent number of the *Journal de Physique*, several devices for obtaining greater precision are described. These are of interest as showing how the course of these rays can be traced in much the same way as rays of light.

For example, a form of tube with two separate and distinct discharge points is now used. These are focussed on the point where the body is expected to lie and by tracing, by the images on the fluorescent screen, the course of the cross-rays from the two sources the position of the body can be exactly determined. Another method is based on observation of the exact points at back and front of the body where the ray enters and departs. The line connecting these points will then pass through the embedded object.

THE PRODUCTION OF LIGHT BY ANIMALS.

A comprehensive paper describing the organs of a variety of insects and animals capable of giving off light in the dark is being contributed by Professor Ulrich Dahlgren to the *Journal of the Franklin Institute*. Many interesting observations on the conditions affecting the production of luminosity are made. There seems to be an extraordinary variety of luminescent insects in different parts of the world and, as is well known, the degree of luminosity produced is in some cases by no means inconsiderable. Mr. F. H. Glew has stated at a recent meeting of the Illuminating Engineering Society that the light of a glow-worm has about the same luminosity as 74 milligramme radium zinc sulphide composition—a strength much, very much, higher than that ordinarily employed, which would probably give a surface brightness approaching half a foot-candle.

Professor Dahlgren states that many luminescent creatures when out hunting their prey have a habit of turning the light on and allowing it to glow for minutes at a time. Whether this is due to the need for a recuperative pause or the deliberate economy on the part of the creature in only turning on the light when it is needed is not stated. In some cases the light is brought into action whenever the creature is disturbed or roughly handled, but gradually subsides when it is left alone.

It is interesting to note that the larvæ during development also exhibit the characteristic glow; in fact, their development can be traced by the waxing and waning of the "larval lights." Just before hatching they light up all over, but do not flash, slowly lighting and darkening.

Professor Dahlgren's researches deal chiefly with the biological side of these phenomena. We should very much like to see a corresponding inquiry into the chemistry of luminescent animals, which might yield some useful hints for practical development.

A COLOUR-SCHEME TO PREVENT CONFUSION OF PIPES.

According to *Popular Mechanics*, a very complicated system of piping, as much as 50 miles in length, and conveying no less than twenty-one different liquids and gases, is used in the Massachusetts Institute of Technology. In order to prevent confusion, it has been found necessary to paint the pipes with different colours so as to indicate their contents. Otherwise there might be some danger, for example, of a person tapping an ammonia pipe when in want of gas or water.

In the large mechanical engineering laboratory the pipes are painted their entire length in characteristic colours. Elsewhere the prevailing colour is white, with light patches of distinguishing colours at intervals. Pipes for water from the Charles River are painted emerald green; for the Cambridge domestic water supply blue, and for the filtered drinking water light yellow. Other colours used are drab for compressed air, black and white for high pressure steam, with another colour at the joints; ultramarine for brine pipes and light green for sulphuretted hydrogen pipes.

INDIRECT GAS LIGHTING IN A CHURCH.

Last year we described the interesting semi-indirect gas lighting installation in the Cathedral of St. Peter and St. Paul, Philadelphia. We notice in the *Gas Age* an account of a similar method of lighting in the Zion Church in Washington.

The fixtures carried 18-inch diffusing glass bowls, equipped with five-mantle burners, the fixtures being hung at a height of 16 ft. 10 in. There is also special lighting in the choir loft, the upper and lower balconies and the side aisles, ribbed white opal globes being here employed.

The installation is illustrative of the tendency towards diffused subdued illumination for churches. It is evidently becoming widely recognised that the leading requirement in such cases is elimination of glare.

CO-OPERATION BETWEEN ENGINEERING SOCIETIES IN THE UNITED STATES.

As is well known, the chief engineering and scientific societies in the United States have for some time been considering methods of taking combined action in matters of common interest.

In the United Engineering Societies building they have already the advantage of a joint meeting place. According to the *Electrical World*, a movement is now on foot to form a United Engineering Societies Council for the purpose of collective utterance and action. In the Conjoint Board of Scientific Societies in this country we have a similar attempt at concerted effort, which in the interests of science and engineering is greatly needed.

A NATIONAL RESEARCH INSTITUTE IN JAPAN.

We notice in the *Electrotechnische Zeitschrift* a reference to the National Research Institute (Rikagaku Kenkyusho) to be established in Japan, which, it appears, was already on the way to completion in 1916.

The field of study for the Institution, for which two million yen has been allotted, is very comprehensive, including many chemical and electro-chemical investigations and such problems as the production of nitrogen from the atmosphere, investigations of steel and metal, and the study of the resources of Japan and its colonial possessions.

It is interesting to note that illumination is one of the subjects specified for study.

MEDICAL CERTIFICATE FOR MUNITIONS WORKERS.

Memorandum No. 16, issued by the Health of Munitions Workers' Committee, deals with medical certificates for munitions workers. It has been found hitherto that certificates have sometimes been made up on odd scraps of paper and do not show the address of the medical officer and other desirable information. In addition, it was sometimes not clear whether the indisposition was slight or temporary merely, or whether it necessitated absence of the worker even from urgent jobs. The Committee therefore present in this memorandum a model form of certificate. It is hoped that the general adoption of this certificate will meet many difficulties at present experienced in dealing with absences of munitions workers on account of illness, and will also provide a basis for the collection of valuable data as to the incidence of different types of illness and as to periods of absence involved

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VISUAL DIFFUSIVITY.

A contribution under the above heading by Dr. H. E. Ives in the *Philosophical Magazine* describes some interesting experiments with sector discs, showing the "recurrent image." If discs of progressively increasing diameter are fitted one behind the other, and thin radial slots are cut in each and illuminated from behind, some curious effects are obtained when the discs are rotated.

For example, if one slot is less bright than the other then it appears to lag behind when the discs are rotated. Similarly if three slots are illuminated respectively with red, green, and blue light, the red slot appears to be in advance of the other two colours, the blue slot being most retarded. By adjusting the displacement between the discs the angle of lag can be measured.

Another effect is the appearance, at weak lights, of a ghostly image following the blue slot at a constant distance behind. This does not occur with red light at all, while at strong illumination the two images gradually approach and coalesce. This retardation and recurrent image Mr. Ives endeavours to explain by a special theory of vision, which assumes that the transmission of impressions to the brain is in accordance with the physical laws of conduction, the diffusivity being different for various colours. Further confirmatory evidence is afforded by the close resemblance between the curve of sensation for the eye, exhibiting an after-image, and the corresponding curve for a short contact transmitted by an electrical transmission line containing both inductance and capacity.

LIGHT AS AN AID TO RECRUITING.

The suggestion is being made in the United States that attractively lighted windows should be devoted to exhibitions for recruiting for the Navy. The *Electrical World* for March 24th illustrates a well-designed concealed lighting exhibit of this type.

TOPICAL AND INDUSTRIAL SECTION.

[At the request of many of our readers we have extended the space devoted to this Section, and are open to receive for publication particulars of interesting installations, new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona-fide* information relating thereto.]

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WORKS LIGHTING.

The above is an illustration of the lighting of the General Offices of the Lodge Sparking Plug Co. with indirect lighting.

In the other sections of the Company's premises different methods are employed according to the nature of the work. For example, for the lighting of tools for small size repetition work localised general lighting with "half-watt" Mazda lamps in Mazdalux reflectors is used.

The equipment, which was installed by the British Thomson-Houston Co., Ltd., Rugby, is thus typical of the varied requirements of a modern factory.

THE TECHNICAL COMMITTEE OF THE MOTOR INDUSTRIES.

We observe that a new Technical Committee, to be known as the Technical Committee of the Motor Industries, has been formed by the Institution of Automobile Engineers and the Society of Motor Manufacturers and Traders in order to co-ordinate the many technical questions which arise in connection with the automobile industry.

The Committee will be strengthened by the addition of representatives nominated by the various Government Departments and Institutions, and is to receive recognition under the Department of Scientific and Industrial Research. Invitations to be represented on the Committee have already been accepted by the National Physical Laboratory, the General Post Office, the Institution of Mechanical Engineers, the Iron and Steel Institute, and the Commercial Motor Users' Association. It is hoped that the formation of the new Committee will be helpful in preventing overlapping, and by bringing about concerted efforts on the part of the various institutions concerned.

Further information may be obtained from the Joint Secretaries, Mr. Basil H. Joy, The Institution of Automobile Engineers, 28, Victoria Street, S.W.1, or Mr. T. F. Woodfine, The Society of Motor Manufacturers and Traders, 83, Pall Mall, S.W.1.

PERSONAL.

Dr. James Kerr, who is associated with the Education Department of the London County Council, and is well known to readers of this journal as a prominent member of the Illuminating Engineering Society, has accepted a Commission as Major in the R.A.M.C.

We understand that Dr. Kerr has taken up his new duties and we wish him every success in his new position.

Dr. Rene Sand, who, after the invasion of Belgium, came to this country, where he has until recently been employed on physiological work, is now attached to the Ambulance de l'Ocean, La Panne, with the Belgian Army.

Dr. Sand has sent us a little publication which he has drafted, entitled "La Médecine sociale en Angleterre," wherein he describes, in sympathetic terms, some of his experiences in England, referring particularly to the widespread voluntary service in regard to social and hygienic matters.

STUDENT CAPTIVES.

A little booklet, issued under the above title, has been written by Mr. Alfred T. Davies, Chairman of the Committee of the British Prisoners of War Scheme (Board of Education).

The object of the scheme is to help prisoners of war by providing them with technical and educational literature, and to enable them to continue their education even under the distressing conditions of captivity. Under the scheme suitable books are regularly sent to prisoners' camps, and it has even been found possible, by the co-operation of the Censor, to conduct examinations from the outside world.

In the national interest it is vital that everything possible should be done to fill this gap, and to provide the intellectual food without which captivity becomes unendurable.

All those who have books of technical, scientific, or educational value which they are willing to place at the disposal of the British Prisoners of War Scheme should communicate with Mr. Davies at the Board of Education. In this direction most of us could do a little to alleviate the suffering caused by the war, and we feel sure that the appeal will evoke an immediate response.

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Particulars on receipt of post card at either of the above Offices.

F. NORIE-MILLER, J.P.
General Manager.

INDEX, April, 1917.

PAGE

American Museum of Safety, Awards of 114
British Science Guild, Annual Meeting 108
Editorial. By L. GASTER 97
Fundamental Principles of Good Lighting. By P. G. NUTTING 119
Good Illumination—An Asset to Supply Companies. By C. E CLEWELL .. 115

Illuminating Engineering Society—
(Founded in London, 1909)

New Members 101
Account of Annual Meeting 101
Report of Council 104

Illuminating Engineering, Short Notes on—
How to secure Efficient and Economical Lighting—Calorific Value of Gas proposed in U.S.A.—Lighting that fits Night Work—More Examples of Flood-lighting—Safety First and the Rule of the Road—Detection of Foreign Bodies by Röntgen Rays—Production of Light by Animals—A Colour-Scheme to prevent Confusion of Pipes—Indirect Gaslighting in a Church—Co-operation between Engineering Societies and the United States—A National Research Institute in Japan—Medical Certificate for Munitions Workers 119

Motor Industries, Technical Committee for 124
Selenium, Properties and Applications of. By E. FOURNIER D'ALBE .. 115
Society of British Industries, Annual Meeting 126
Student Captives of War 124
Sunlight and Moonlight, Relation between. By J. S. DOW 113
Topical and Industrial Section:—
B.T.H. Industrial Installation—Buses run with Gas—Application of Gas in War Industries 126

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This Coupon must not be cut out but left intact in THE ILLUMINATING ENGINEER as that, being dated, forms the only evidence of its currency.

USE GAS AND SAVE COAL.

A recent statement issued by the Ministry of Munitions refers to the desirability of economising in coal by using gas or coke wherever possible. In this way the valuable by-products recovered in the production of gas from coal are preserved and the waste inevitable in the ordinary coal fire is avoided.

It is stated that efforts are now being made to place adequate supplies of coke at the disposal of the public.

BUSES RUN WITH GAS.

Much interest has been taken in experiments that are being made with a view to the use of gas in internal combustion motors on lorries, &c. The gas is readily stored by compression, and we understand that promising results are already being obtained.

In the *Gas World* reference was recently made to the experience of the Grimsby Tramways Co., where a bus worked in this way has been running quite satisfactorily. The bag contains about 500 cubic feet of gas, which is ample for a double journey, and the gas is used with the motor previously used for petrol.

THE SOCIETY OF BRITISH GAS INDUSTRIES.

At the annual meeting of the Society of British Gas Industries, on April 17th, an address was given by the President, Sir Robert Hadfield, dealing chiefly with Patent Laws, while Mr. H. A. Bennie Gray discussed "The Education and Training of Engineering Apprentices."

Mr. Gray pointed out the absurdity of expecting apprentices to attend night classes after an exhausting day in the shops. Provision should be made for their education during working hours. An interesting departure in this direction has been made in Huddersfield, where the engineering employers decided to equip, at their own expense, an up-to-date engineering department at the local technical college for the use of pupils The progress of each apprentice was closely followed, and opportunities were provided, in the form of scholarships, for the most gifted to continue in more advanced courses.

The results of this step had already been most satisfactory. It was expected that in future, as a result of such training, the output of engineering works would be considerably increased, even though the working week was diminished to fifty-four hours.

THE APPLICATION OF COAL GAS IN WAR INDUSTRIES.

Lecturing before the Royal Society of Arts on April 18th, Mr. H. M. Thornton gave some interesting details of the uses of gas in munitions work, notably in the form of furnaces employed in dealing with large guns, rifle barrels, &c., and the treatment of high speed steel. A remarkable fact had been the increase in gas consumption since the outbreak of war, tables for leading gas companies showing advances of 28, 57, 64, 72, 84, 100, 112, and 154 per cent. Of great importance, also, was the use of gas in welfare work, in canteens, swimming baths, gymnasia, &c.

Finally, Mr. Thornton referred to the many special uses being discovered for derivatives in coal gas manufacture. It was quite possible that in the future gas might itself become a "by-product," and the materials now classed as by-products might become the chief items in manufacture.